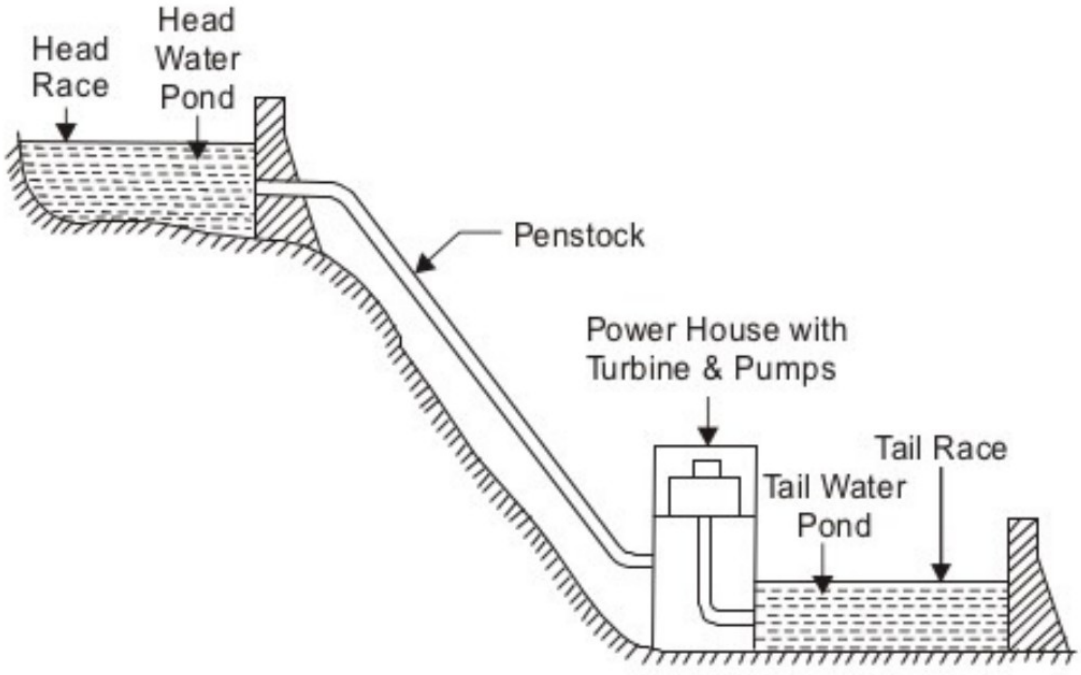
Energy Engineering (18ME81)
IAT – 01 Solutions

Q1) With a neat diagram, explain pumped storage plant.

Pumped Storage Power Plants: These plants supply the peak load for the base load power plants and pump all or a portion of their own water supply. The usual construction would be a tail water pond and a head water pond connected through a penstock. The generating pumping plant is at the lower end. During off peak hours, some of the surplus electric energy being generated by the base load plant, is utilized to pump the water from tail water pond into the head water pond and this energy will be stored there. During times of peak load, this energy will be released by allowing the water to flow from the head water pond through the water turbine of the pumped storage plant. These plants can be used with hydro, steam and i.e. engine plants. This plant is nothing but a hydraulic accumulator system. These plants can have either vertical shaft arrangement or horizontal shaft arrangement. In the older plants, there were separate motor driven pumps and turbine driven generators. The improvement was the pump and turbine on the same shaft with the electrical element acting as either generator or motor. The latest design is to use a Francis turbine which is just the reverse of centrifugal pump. When the water flows through it from the head water pond it will act as a turbine and rotate the generator. When rotated in the reverse direction by means of an electric motor, it will act as a pump to shunt the water from the tail water pond to the head water pond. The efficiency of such a plant is never 100 per cent. Some water may evaporate from the head water pond resulting in the reduction in the stored energy or there might be run off through the soil.

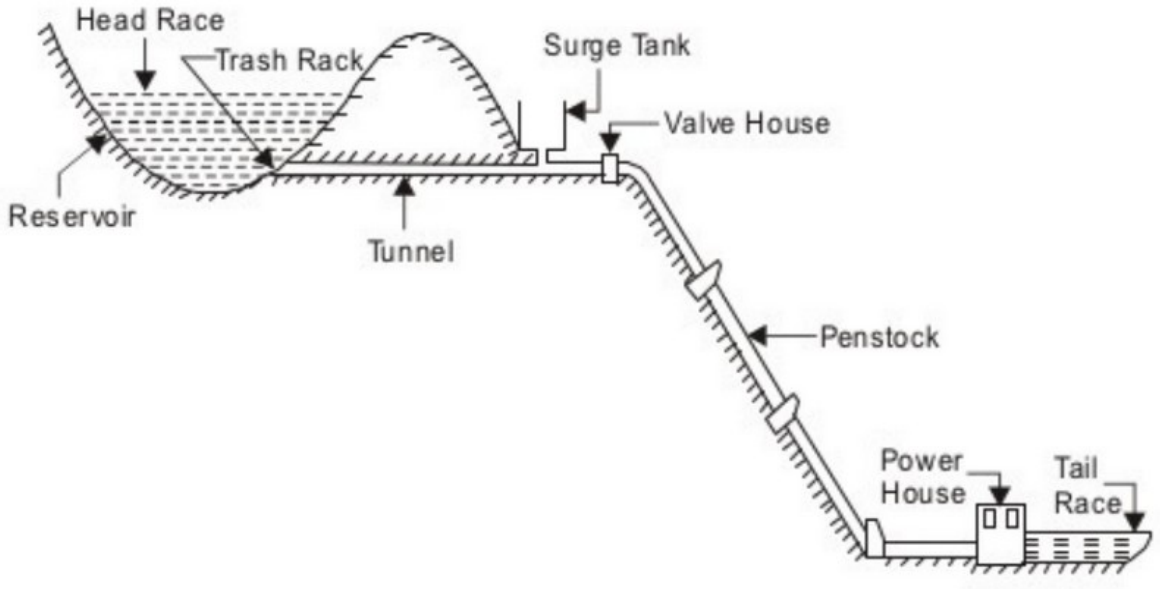


Classify the hydroelectric power plants on the basis of head. Explain any one type of plant in detail.

The power plant can be classified on the basis of head roughly in the following manner:

- High head plants: About 100 m and above.
- Medium head plants: about 30 to 500 m.
- Low head plants: Up to 50 m.

High Head Plants: A hydel plant with a water head of more than 100 meters is termed a high head plant. In this case, the water from the main reservoir is carried through tunnels up to the surge tank, from where it is taken through the penstock. Since the water head is very high, the effect of water hammer is too severe in such plants. Thus, it is essential to provide a surge tank in the water line at appropriate location. The surge tank takes care of the increasing and decreasing water levels during the low-demand and high demand periods, respectively. The function of the surge tank is to prevent a sudden pressure rise in the penstock when the load on the turbines decreases and the inlet valves to the turbines are suddenly closed. In the valve house, the butterfly valves or the sluice type valves control the water flow in the penstocks and these valves are electrically driven. Gate valves are also there in the power house to control the water flow through the turbines after flowing through tile turbines. The water is discharged to the tail race. The Pelton wheel turbine is most suitable for high head plants.



Q3) List the advantages, limitation and application of Hydel Power Plant.

Advantages of Hydro-electric Power Plant:

- Water is the cheapest and reliable source of generation of electric power because it exists as a free gift of nature.
- There are no ash disposal problems. Also the atmosphere is not polluted because no smoke is produced in this plant.
- No fuel transportation problem.
- It can take up the loads quickly and it is capable of meeting the variable loads without
- any loss in efficiency.
- Its maintenance cost is low.
- It requires less supervising staff.
- Auxiliaries needed in the plant are less as compared to steam plant of equal size.

Disadvantages: The various disadvantages are as follows:

- The power produced by the plant depends upon quantity of water which in turn is dependent upon the rainfall, so if the rainfall is in time and proper and the required amount of water can be collected, the plant will function satisfactorily otherwise not.
- Hydro-electric plants are generally situated away from the load centers. They require long transmission lines to deliver power. Therefore, the cost of transmission lines and losses in them will be more.

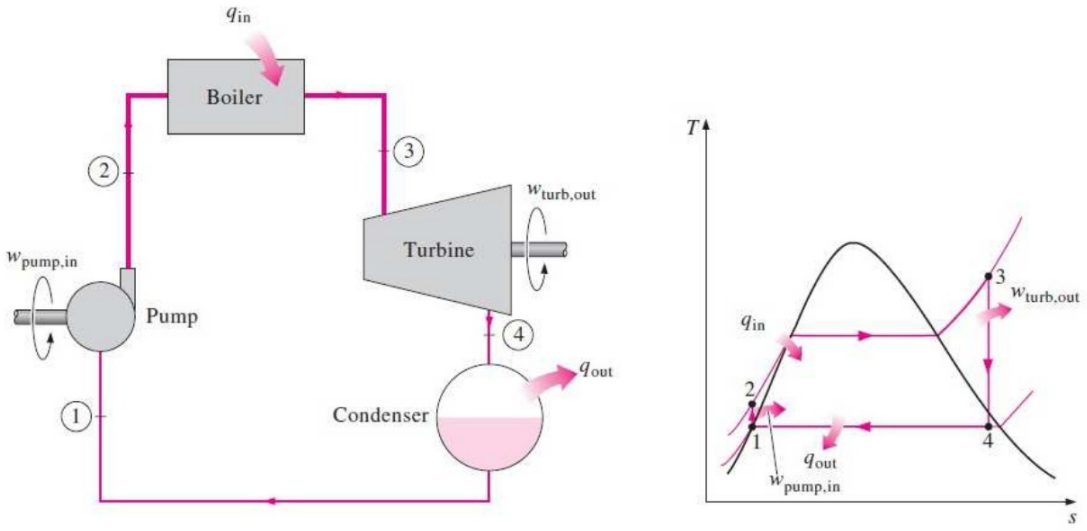
- Initial cost of the plant is high.
- It takes fairly long time for the erection of such plants.

The applications of Hydroelectric Power Plant include:

- Unlike other source of energy, Hydroelectric Power Plant helps in generating Eco Friendly Energy.
- They help in creating Recreational Facilities.
- It also helps in Flood Risk Management.
- The water from the dam is used for Agricultural Irrigation Facility.
- It helps in generating revenue as the location of the Plant creates a tourist spot.

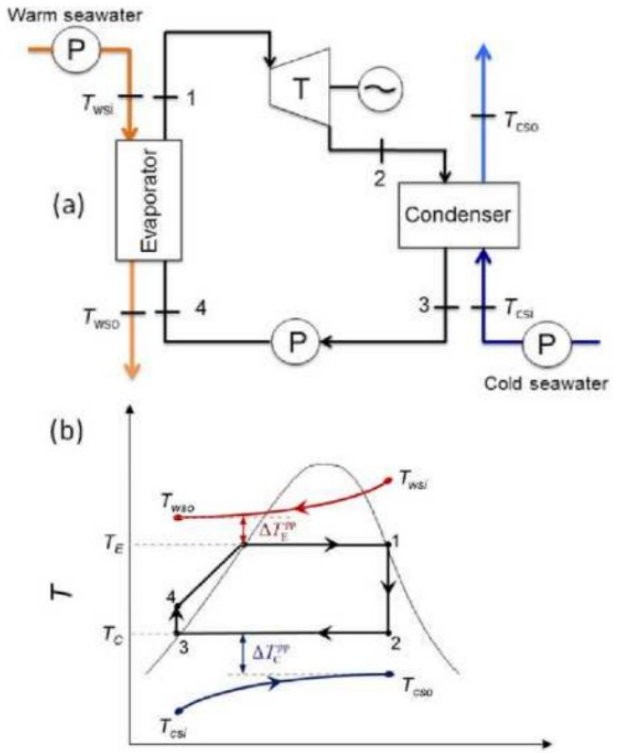
Q4) Explain the principle of harnessing energy from ocean thermal energy.

The origin of OTEC may be traced to solar radiation on ocean surface. In fact the ocean is the world's largest solar collector. Therefore, the resource is virtually inexhaustible source of energy. Absorption of solar energy in water takes place according to Lambert's law of absorption. Almost all the absorption occurs very close to the surface raising its temperature while deep water at about 1000 m or so remains cool and unaffected by the solar radiation. There will be no thermal convection currents between the warmer, lighter water at the surface and cooler, heavier deep water. Also heat transfer through thermal conduction across the large depth is too low. Thus mixing is retarded and so warm water stays at the top providing a huge heat source while cold water stays at depth providing a huge heat sink. Both reservoirs are maintained annually by solar radiation.



The Rankine cycle is an idealized thermodynamic cycle describing the process by which certain heat engines, such as steam turbines or reciprocating steam engines, allow mechanical work to be extracted from a fluid as it moves between a heat source and heat sink. Heat energy is supplied to the system is used to convert the working fluid in liquid state to a high pressure gaseous state in order to turn a turbine. After passing over the turbine the fluid is allowed to condense back into a liquid state as waste heat energy is rejected before being returned to boiler, completing the cycle. The ability of a Rankine engine to harness energy depends on the relative temperature difference between the heat source and heat sink. The greater the differential, the more mechanical power can be efficiently extracted out of heat energy.

Q5) With a neat sketch, explain the closed cycle OTEC System (Anderson cycle).



In closed cycle (also known as Anderson cycle) plant, warm surface water is used to evaporate a low boiling point working fluid such as ammonia, freon or propane. The vapor flows through the turbine and is then cooled and condensed by cold water pumped from the ocean depths. Because of low quality heat a large surface areas of heat exchangers (evaporator and condenser) are required to transfer significant amount of heat and large amount of water need to be circulated. The schematic diagram of closed loop OTEC plant is shown is figure. The operating pressures of the working fluid at the boiler/evaporator and condenser are much higher and its specific volume is much lower as compared to water in open cycle system. Such pressures and specific volumes result in turbine that is much smaller in size and hence less costly as compared to that in open cycle system. Although both systems are being explored, the closed cycle system appears to be more promising in near future.